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Estimating the cost of community interventions to reduce child mortality in South Africa using the Lives Saved Tool (LiST)

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Abstract

Objective To estimate the costs of scaling up interventions that can be undertaken at community level and to estimate the overall impact that the interventions can have on reducing child mortality.

Setting In this study we used the Lives Saved Tool (LiST), a module in the spectrum software. Within the spectrum software, LiST interacts with other modules, the AIDS Impact Module (AIM), Family Planning Module (FamPlan) and Demography Projections Module (Dem Proj), to model the impact of more than 60 interventions that affect cause-specific mortality.

Participants Demography Projections Module Based on National South African Data

Interventions A total of 9 interventions namely; Breastfeeding promotion, Complimentary feeding, Vitamin supplementation, Hand washing with soap, Hygienic disposal of children's stools, Oral rehydration solution, Oral antibiotics for the treatment of pneumonia, Therapeutic feeding for wasting, and Treatment for moderate malnutrition.

Primary and secondary outcome measures Reducing child mortality

Results A total of 9 interventions can prevent 8, 891 deaths by 2030. Hand washing with soap (21%) accounts for the highest number of deaths prevented, followed by therapeutic feeding (19%) and oral rehydration therapy (16%). The top 5 interventions account for 77% of all deaths prevented. At scale, an estimated cost of R2.2 billion (R41 per capita) per year will be required in community health worker costs.

Conclusion The use of community health workers offers enormous opportunities for saving lives. These programmes require appropriate financial investments. Findings from this study show what can be achieved if concerted effort is channelled towards the identified set of life saving interventions.

Strengths and limitations of this study

- This analysis estimates both the cost and impact of interventions delivered at community level to prevent child mortality
- This study aids priority setting, it identifies the top 5 interventions out of the 9 that account for 82% of all additional deaths prevented
- The 9 interventions are included in the model as stand-alone interventions and they are not included as the package of interventions

Background

Thousands of children die every year in South Africa from preventable causes, mainly diarrhoea and pneumonia [1,2]. Progress has been made in the last decade, with child and infant mortality reducing significantly between 2009 and 2012 [3]. This progress has occurred at a time during which there has been rapid scale up of prevention of mother to child transmission (PMTCT) of HIV and improvement in the coverage of other essential child health interventions including immunisations and increased access to water and sanitation. However, this has not been sufficient to reach the country's millennium development goals of reducing infant and under-five mortality rates by two thirds by 2015.

As the country looks to a new set of sustainable development goals beyond 2015, there is need to focus on essential interventions that have been shown to be effective in improving child health. Recent analyses in South Africa identified a set of priority interventions that can have an impact on stillbirths [4], maternal, newborn and child mortality [5]. Interventions such as family planning can avert more than 7,000 newborn and child lives, at a cost of US$7 per year per user of family planning [6]. Investing an additional US$9 to US$18 per capita in 13 interventions to prevent diarrhoea can save more than 3,000 additional child lives every year [7]. Scaling up these essential maternal and child health interventions will require concerted effort and a strengthening of the health system, a process which has already been initiated by the government.

In 2011, South Africa initiated its primary healthcare (PHC) reengineering programme in a bid to improve health systems performance and access to health. PHC re-engineering is aimed at positioning PHC as the mainstay of the health sector in responding to the quadruple burden of disease (HIV/TB; maternal and child health; non-communicable burden of disease; and violence and injury). South Africa's approach to PHC reengineering relies heavily on PHC outreach teams which include professional nurses, health promotion practitioners and community health workers (CHWs).

Global evidence has shown that CHWs can effectively deliver interventions in primary health care including nutrition, maternal and child health, malaria control, tuberculosis (TB) control, HIV/AIDS prevention and control, mental health and non-communicable disease [8-13]. A Cochrane review of CHW interventions identified 107 randomised controlled trials which showed promising benefits, compared to usual facility care in increasing immunisation uptake in children, improving breastfeeding rates until six months, reducing neonatal mortality and improving pulmonary TB care rates [14]. The review also reported that CHWs interventions reduce child morbidity and mortality; maternal mortality; and increase the likelihood of caregivers seeking care for children who are ill.

There is a small but growing evidence base of cost effectiveness studies of CHW interventions in low and middle income countries [15-17]. More recently there is evidence of the cost-effectiveness of CHW interventions in reducing malaria and asthma [16,17], mortality of neonates and children [16,17], malnutrition [16,17], improving maternal health [17], and increasing exclusive breastfeeding [17-19], increasing uptake of home based HIV testing [20] and improving children's physical health and psychomotor development [17]. However, there is still a need to provide more information on the cost and impact of community health worker interventions, in order to aid priority setting and decision making for the improvement of child health.

In this paper, we use the Lives Saved Tool (LiST), a widely used priority setting tool, to estimate the costs of scaling up interventions that can be undertaken at community level [21]. The paper describes the methods used in LiST to estimate the cost of deploying community health workers and the overall impact that interventions can have on reducing child mortality. This information is necessary for South Africa, as it pursues the goal of Universal Health Care.

Methods

This analysis used the Lives Saved Tool (LiST), a module in the Spectrum software, which models the impact of increased coverage of health interventions on maternal, newborn and child mortality [21]. Within the Spectrum software, LiST interacts with other modules, the AIDS Impact Module (AIM), Family Planning Module (FamPlan) and Demography Projections Module (DemProj), to model the impact of more than 60 interventions that affect cause-specific mortality [22]. LiST is a deterministic mathematical model that compares the effect of various interventions on population level risk factors, as well as stillbirths and maternal, newborn and child deaths [21,23]. The primary model inputs are coverage of interventions and the outputs are changes in risk factors (such as stunting rates) and cause specific mortality. Interventions included in the model can have an impact on single or multiple causes of death and risk factors, with outcomes changing based on the level of intervention coverage. Increasing the level of coverage of one or more interventions can thus lead to a reduction in associated risk factors or cause-specific mortality.

Intervention impact on mortality can be direct or indirect (through the reduction of risk factors). The direct impact of each of these interventions is modelled by multiplying its effectiveness estimate with the level of coverage, assuming all other interventions are kept constant. For example, an intervention with an effect estimate of 30% can avert 30% of the associated cause-specific deaths if coverage for that intervention is 100%.

The modelling methods used in LiST have been widely reviewed [24,25]. In South Africa, LiST has been used to identify the potential cost and impact of scaling up interventions on stillbirths [4], diarrhoea [26] and maternal, newborn and child mortality [5,27]. In our model, we use LiST to model the impact of interventions to reduce child mortality and then estimate the resources required for the portion of interventions that are delivered at community level [28]. All interventions are scaled up from their baseline levels (2015) to full coverage at 99% (2030).

Nine interventions (described in Table 1) that can be delivered both at community and facility level, and have been shown to effectively impact child mortality are used in the model (Table 2). The baseline mortality rates used were 41 deaths per 1,000 live births for under-five children and 13/1,000 for neonates [29]. The causes of newborn and child mortality [30] are given in Figure 1. Table 2 also shows the percent delivery of each intervention at different levels in the base and target years. Taking promotion of breastfeeding for example, the table shows that in the base year, the coverage of this intervention is 25% and will be scaled up to 99% in the target year 2030. In the base year, breastfeeding promotion is delivered 50% at community level and 25% each at outreach and clinic levels. Setting the percent delivery is essential to determining the resource requirements at the different levels. It is also important to note that LiST models the overall impact of each intervention, and intervention impact does not take into consideration the model of delivery (whether delivered at community or facility level).

Estimation of costs and resource requirements

Costs were modelled from a provider perspective, using the costing module in LiST. The module uses an ingredients approach to costing, based on four components: personnel and labour; drugs and supplies; other recurrent costs; and capital costs. In the analysis for costs of community health workers, the items included are personnel and labour and drugs and supplies. Staff remuneration is based on current salary structures of health workers in South Africa, with an allowance made for

annual cost of living adjustments at 5.6% per annum [31]. The unit costs of drugs and supplies are based on international drug prices from UNICEF and the Management for Sciences Health International Drug Price Indicator [32,33].

The primary personnel input in LiST are staff time, which is then converted to annual staff costs. Thus, LiST cannot for example calculate the number of personnel required for a particular intervention, but can be used to estimate the effort required to scale up an intervention (in terms of staff time).

Costs were estimated in South African Rand (ZAR) and converted to United States Dollars (US$), at an average exchange rate of US$1 to ZAR11 in 2014.

Results

Overall intervention impact on child mortality

Table 3 provides the estimated number of deaths at baseline in 2015 and after full scale in 2030. The number of deaths reduces from approximately 40,000 in 2015 to 30,000 in 2030. There are a total of 8,322 deaths prevented in 2030 by the 9 interventions scaled up in this analysis (Table 4). Hand washing with soap (22%) accounts for the highest number of deaths prevented, followed by therapeutic feeding (21%) and ORS (17%). The top 5 interventions account for 82% of all deaths prevented.

Estimations of resource requirements

The total costs of all the interventions used in the analysis (including costs of all delivery channels i.e. community, outreach and health facility) are estimated to be R964 million (R18 per capita) in 2015. This is expected to rise to R7.3 billion (R136 per capita) if interventions are scaled up to 99%

coverage in 2030. In comparison, the costs of community component are R258 million (R5 per capita) in 2015 and R2.2 billion in 2030. Using an annual salary of about R54, 600 per annum per community health worker, the required community health workforce would be about 4,700 at baseline and 40,300 at full coverage.

Considering only the baseline costs at community level, hygienic disposal of stools was estimated to have the highest cost of labour at R73.6 million. Therapeutic feeding for wasting came in second at R73 million and oral rehydration solution had the third highest cost of R33 million. When interventions are at scale in 2030, the costs are for treatment of moderate acute malnutrition (R703.8 million), hand washing with soap and disposal of stools (R484 million each) and therapeutic feeding for wasting (R352 million).

Approximately 3.3 million hours of work per year at the community level are required at baseline, compared to 11.1 million hours when interventions are fully scaled up.

Discussion

This analysis used the Lives Saved Tool (LiST), a widely used priority setting tool, to estimate the cost and impact of interventions delivered at community level to prevent child mortality. LiST has been previously used in South Africa to identify the essential interventions that can save the lives of children, together with the costs of these interventions [5-7,26,27]. It has also been used in other low and middle income countries to assess the cost-effectiveness of community health worker programmes [15]. This current analysis shows that scaling up 9 interventions that are conducted at both community and facility level can prevent an additional 8,300 lives per year. The top 5 interventions: hand washing with soap, therapeutic feeding for wasting, ORS, oral antibiotics for pneumonia and appropriate complementary feeding, account for 82% of all additional deaths

prevented i.e. implementing only these 5 interventions at scale can prevent an additional 6,800 child deaths per year.

This is an important finding as it has implications for considerations when choosing the most effective interventions to meet the new sustainable development goals for child health. Considering that not all interventions can be fully implemented given budgetary constraints, focusing on the identified 5 most effective interventions can contribute to achieving the desired results. Other considerations such as cost implications have to be made when choosing which interventions to implement.

In 2011, it was estimated that there were more than 72,000 community health workers in South Africa, delivering various interventions [34]. In our projection, we estimated that approximately 40,000 community health workers would be required to deliver the 9 interventions used in this analysis at scale. This could be an underestimate, and we have no basis for comparisons with other studies. Caution should be taken when considering our estimate, because it is based on a projected baseline level of coverage for the modelled interventions, level of effort required to deliver the interventions and an annual salary, all of which could be different in other models.

The labour costs of community health workers have been provided in this analysis. We show that at scale, an estimated cost of R2.2 billion (R41 per capita) per year will be required. The top 5 most effective interventions are also the most costly, probably because they are more personnel intense, with a lot of time spent on extensive demonstrations. Provision of oral antibiotics for example requires diagnosis, treatment and follow up. It is important to note though, that the overall cost of an intervention will be influenced by among other things, the level of coverage, with more effort required to scale up low coverage interventions.

The costs provided in this analysis are likely an underestimate of the true costs of deploying community health workers, which have been shown to be substantial. Equipment costs have not been included, nor have the usually large administrative costs also been considered. Future research should look into providing the overall cost structure as this has important implications for how health workers are deployed and accounted for. Future analyses should take these costs into consideration, as it has been shown that they can contribute to the overall cost-effectiveness of interventions [19,35].

This analysis also had a limitation in that it did not consider the interventions included as part of a package of interventions that can be delivered by a single health worker. The interventions are standalone. Considering a synergistic approach to providing services could be useful particularly in terms of reducing costs. However, other considerations should also be made on how this would work and on whether a health worker loaded with several different messages to deliver to a home will be as effective as one who is focused on one specific message, e.g. breastfeeding promotion.

Further, though this analysis provided information on the cost of interventions that can be undertaken at the community level, it did not in itself provide an assessment of the effectiveness of using community health workers to deliver the said interventions. When analysing community interventions using LiST, it is not immediately possible to isolate the impact of adding the community health component on mortality outcomes. The impact of an intervention is based on its overall potential to reduce a particular risk factor, not on its delivery channel (i.e. community or facility). In a trial for example, it may be possible to assess the impact of delivering breastfeeding promotion through community health workers or nurses at a clinic. What is possible with LiST is an assessment of the resources that are required at various levels of service delivery. Thus one can estimate the number of minutes required for community health interventions, the labour costs and total number of services.

We focused on only 9 interventions that can be delivered at community level, by maintaining constant coverage of other child health interventions. This may not be very realistic since in the real world, coverage of the other interventions is likely to increase, resulting in a lower burden of under-five mortality by 2030. It is therefore possible that we have overestimated the total number of deaths prevented.

Furthermore, the LiST model assumes that the health system interventions are delivered at uniformly high quality. This is unlikely given drug shortages, health care worker attitudes and institutional challenges. Significantly more resources are probably required to address such issues.

Conclusion

South Africa has made significant progress with regard to reducing child mortality although this was not sufficient to meet the MDG deadline in 2015. As the new sustainable development goals materialise, and South Africa heads towards Universal Health Care, understanding what the best package is and how it can be delivered is essential. In order to do this, there is need to consider essential and effective interventions that will have the most impact on saving the lives of South African children. In this paper, we have provided information on the cost and impact of 9 effective interventions that can be delivered at community level. We show that implementing just 5 of these interventions can prevent as many as 6,800 additional deaths of children every year. The community health worker costs of implementing the 9 interventions do not seem to be substantial, at R41 per capita. This seems to be well within the scope and affordability of the South African health budget.

Contributorship statement

LN and KH conceived the study and participated in the design. LN and LC conducted the analysis of the analysis of the data. All authors participated in interpretation of data, drafting and critical revision of the manuscript, and approved the final version.

Competing interests

None declared

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Data sharing statement

The model data can be made available to interested researchers. No additional data available.

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Table 1: Description of interventions

Intervention	Description of the intervention
1. Breastfeeding promotion	Breastfeeding promotion can be either one-on-one or group meetings. It is assumed that children 1-5 months of age who are exclusively breast fed do not need breastfeeding promotion.
2. Complimentary feeding	This intervention only benefits children 6-24 months of age who are living on more than a dollar a day; This can be delivered in the home, community or clinic, by health professionals or health volunteers. It includes the assumption that breast feeding should be continued for children 6-24 months of age, (but does not affect breast feeding rates). The intervention includes education on the proper foods to prepare as well as appropriate hygiene for food preparation.
3. Vitamin A supplementation	This intervention covers the percent of children 6-59 months receiving full coverage with Vitamin A. Full coverage of Vitamin A supplementation is considered to be 2 doses of Vitamin A in the past year. It is assumed that all children in a country with Vitamin A deficiency are in need of Vitamin A for prevention.
4. Hand washing with soap	Appropriate hand washing is defined as washing hands with soap, ash or other materials and using adequate water, after handling faeces and before preparing food.
5. Hygienic disposal of children's stools	Percent of children's stools that are disposed of safely and contained. Stools are considered to be contained if: 1) the child always uses a toilet/latrine, 2) the faeces are thrown in the toilet or latrine, or 3) the faeces are buried in the yard.
6. Oral rehydration solution (ORS)	Percent of children with diarrhoea given ORS from sachets. This includes sachets or pre-mixed solutions of ORS.
7. Oral antibiotics for the treatment of pneumonia	Proportion of children 1-59 months with suspected pneumonia or ARI treated with antibiotics
8. Therapeutic feeding for wasting	Percent of wasted children receiving therapeutic feeding. Therapeutic feeding is outpatient treatment for severely wasted children (<-3Z) including supplementation with food (such as PlumpyNut) and maternal education. Therapeutic feeding is only applied to the percent of children severely wasted. It shifts children from the severely wasted category to moderately (-3to-2Z) and mildly (-2to-1Z) wasted categories.
9. Treatment for moderate malnutrition	Percent of moderately wasted children (-3to-2Z) receiving outpatient treatment including supplementation with food (such as PlumpyNut) and maternal education. Treatment for MAM shifts children from the moderately wasted category into the mildly wasted category (-2to-1Z).

Table 2: Percent intervention coverage and delivery at different levels

	Coverage		Delivery channels					
			Community		Outreach		Clinic	
Interventions	Baseline year	Target year	Baseline year	Target year	Baseline year	Target year	Baseline year	Target year
Promotion of breastfeeding	25	99	50	50	25	25	25	25
Complementary feeding--education only	10	99	50	50	0	0	50	50
Vitamin A supplementation	50	99	50	50	50	50	0	0
Hand washing with soap	17	99	100	100	0	0	0	0
Hygienic disposal of children's stools	40.5	99	100	100	0	0	0	0
ORS - oral rehydration solution	50	99	50	50	0	0	50	50
Oral antibiotics : case management of pneumonia in children	73.2	99	50	50	0	0	50	50
Therapeutic feeding - for severe wasting	45	99	20	20	0	0	80	80
Treatment for moderate acute malnutrition	10	99	20	20	0	0	80	80

Table 3: Total number of deaths

	2015	2030
<1 month	13356	12435
1-59 months	26857	17569
Total (0-60 months)	40214	30004

Table 4: Additional deaths prevented by intervention, 2030

Intervention	Number of deaths prevented	% deaths prevented
Hand washing with soap	1828	22%
Therapeutic feeding - for severe wasting	1730	21%
ORS - oral rehydration solution	1426	17%
Oral antibiotics : case management of pneumonia in children	1025	12%
Appropriate complementary feeding	822	10%
Hygienic disposal of children's stools	543	7%
Vitamin A supplementation	394	5%
Promotion of breastfeeding	319	4%
Treatment for moderate acute malnutrition	235	3%
Total	8322	100%

Table 5: Costs and resource requirements

	2015		2030	
	Total	Community	Total	Community
Intervention costs (ZAR)				
Promotion of breastfeeding	14,605,614	7,302,807	130,496,248	65,248,124
Complementary feeding (education only)	14,941,369	1,595,365	333,830,200	35,644,735
Vitamin A supplementation	7,142,477	934,263	31,126,779	3,647,176
Hand washing with soap	30,881,088	30,881,088	487,840,894	487,840,894
Hygienic disposal of children's stools	73,569,651	73,569,651	487,840,894	487,840,894
Oral rehydration solution	250,514,043	33,477,411	448,502,768	53,123,952
Oral antibiotics : case management of pneumonia in children	42,881,508	4,925,812	130,592,593	14,390,511
Therapeutic feeding - for severe wasting	366,777,062	73,080,754	1,765,928,290	351,808,218
Treatment for moderate acute malnutrition	163,145,576	32,507,045	3,533,114,183	703,867,957
Total	964,458,387	258,274,196	7,349,272,850	2,203,412,461
Personnel time (minutes)				
Community health workers		3,339,796		11,140,869

Total costs include costs of all delivery channels (community, outreach and health facility).
ZAR=South African Rand

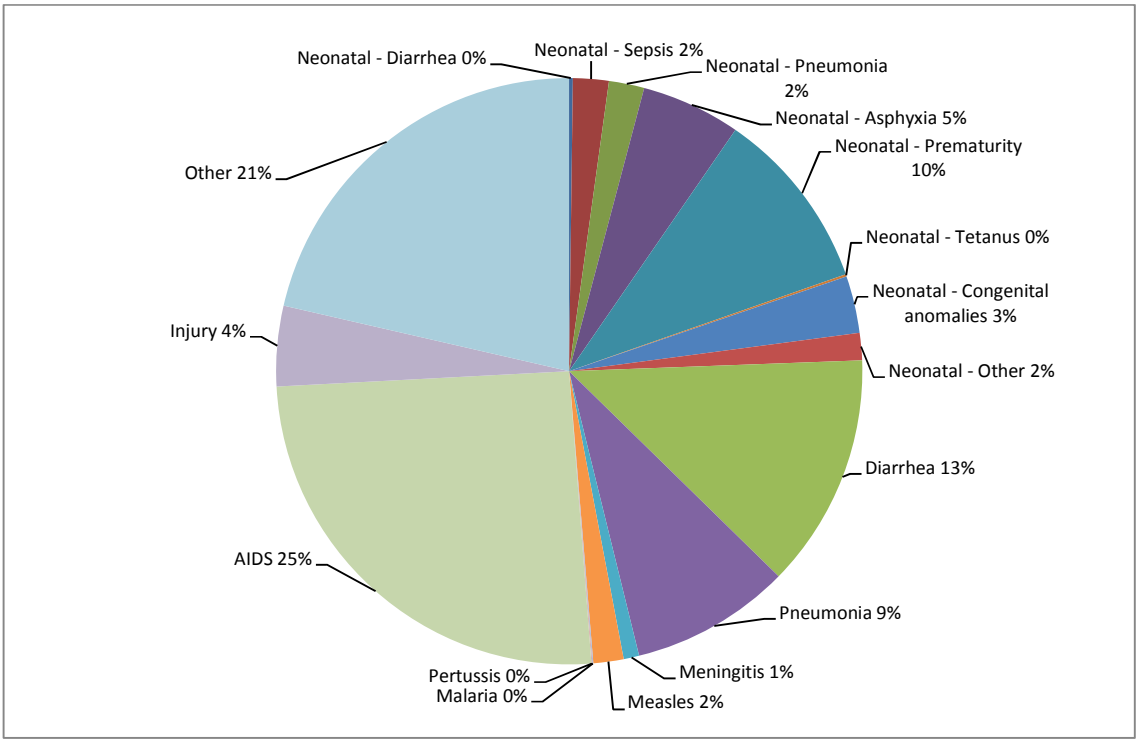

Figure 1: Causes of death in children under-five years, used in LiST (adapted from MRC, 2010).

CHEERS Checklist
Items to include when reporting economic evaluations of health interventions

The **ISPOR CHEERS Task Force Report**, *Consolidated Health Economic Evaluation Reporting Standards (CHEERS)—Explanation and Elaboration: A Report of the ISPOR Health Economic Evaluations Publication Guidelines Good Reporting Practices Task Force,* provides examples and further discussion of the 24-item CHEERS Checklist and the CHEERS Statement. It may be accessed via the *Value in Health* or via the ISPOR Health Economic Evaluation Publication Guidelines – CHEERS: Good Reporting Practices webpage: http://www.ispor.org/TaskForces/EconomicPubGuidelines.asp

Section/item	Item No	Recommendation	Reported on page No/ line No
Title and abstract			
Title	1	Identify the study as an economic evaluation or use more specific terms such as "cost-effectiveness analysis", and describe the interventions compared.	Pg 1, line 1-2
Abstract	2	Provide a structured summary of objectives, perspective, setting, methods (including study design and inputs), results (including base case and uncertainty analyses), and conclusions.	Pg 2, line 21-40
Introduction			
Background and objectives	3	Provide an explicit statement of the broader context for the study. Present the study question and its relevance for health policy or practice decisions.	Pg 4-5, line 85-100
Methods			
Target population and subgroups	4	Describe characteristics of the base case population and subgroups analysed, including why they were chosen.	Pg 6, line 126-130
Setting and location	5	State relevant aspects of the system(s) in which the decision(s) need(s) to be made.	Pg 6, line 132-138
Study perspective	6	Describe the perspective of the study and relate this to the costs being evaluated.	????
Comparators	7	Describe the interventions or strategies being compared and state why they were chosen.	Pg 6, line 124-127
Time horizon	8	State the time horizon(s) over which costs and consequences are being evaluated and say why appropriate.	Pg 6, line 124-127
Discount rate	9	Report the choice of discount rate(s) used for costs and outcomes and say why appropriate.	Not applicable
Choice of health outcomes	10	Describe what outcomes were used as the measure(s) of benefit in the evaluation and their relevance for the type of analysis performed.	Pg 6, line 127-130
Measurement of effectiveness	11a	*Single study-based estimates:* Describe fully the design features of the single effectiveness study and why the single study was a sufficient source of clinical effectiveness data.	Not applicable

			Not applicable
	11b	*Synthesis-based estimates:* Describe fully the methods used for identification of included studies and synthesis of clinical effectiveness data.	Not applicable
Measurement and valuation of preference based outcomes	12	If applicable, describe the population and methods used to elicit preferences for outcomes.	Not applicable
Estimating resources and costs	13a	*Single study-based economic evaluation:* Describe approaches used to estimate resource use associated with the alternative interventions. Describe primary or secondary research methods for valuing each resource item in terms of its unit cost. Describe any adjustments made to approximate to opportunity costs.	Pg 5, line 114-152
	13b	*Model-based economic evaluation:* Describe approaches and data sources used to estimate resource use associated with model health states. Describe primary or secondary research methods for valuing each resource item in terms of its unit cost. Describe any adjustments made to approximate to opportunity costs.	Pg 5, line 154-155
Currency, price date, and conversion	14	Report the dates of the estimated resource quantities and unit costs. Describe methods for adjusting estimated unit costs to the year of reported costs if necessary. Describe methods for converting costs into a common currency base and the exchange rate.	Pg 7, line 157-158
Choice of model	15	Describe and give reasons for the specific type of decision-analytical model used. Providing a figure to show model structure is strongly recommended.	Pg 5-6, line 120-152
Assumptions	16	Describe all structural or other assumptions underpinning the decision-analytical model.	Pg 6, line 143-158
Analytical methods	17	Describe all analytical methods supporting the evaluation. This could include methods for dealing with skewed, missing, or censored data; extrapolation methods; methods for pooling data; approaches to validate or make adjustments (such as half cycle corrections) to a model; and methods for handling population heterogeneity and uncertainty.	Pg 6, line 127-138
Results			
Study parameters	18	Report the values, ranges, references, and, if used, probability distributions for all parameters. Report reasons or sources for distributions used to represent uncertainty where appropriate. Providing a table to show the input values is strongly recommended.	Pg 7, line 167-183
Incremental costs and outcomes	19	For each intervention, report mean values for the main categories of estimated costs and outcomes of interest, as well as mean differences between the comparator groups. If applicable, report incremental cost-effectiveness ratios.	Pg 7, line 167-183
Characterising uncertainty	20a	*Single study-based economic evaluation:* Describe the effects of sampling uncertainty for the estimated incremental cost and incremental effectiveness parameters, together with the impact	Not applicable

			Not applicable
		of methodological assumptions (such as discount rate, study perspective).	Not applicable
	20b	*Model-based economic evaluation:* Describe the effects on the results of uncertainty for all input parameters, and uncertainty related to the structure of the model and assumptions.	Not applicable
Characterising heterogeneity	21	If applicable, report differences in costs, outcomes, or cost-effectiveness that can be explained by variations between subgroups of patients with different baseline characteristics or other observed variability in effects that are not reducible by more information.	Not applicable
Discussion			
Study findings, limitations, generalisability, and current knowledge	22	Summarise key study findings and describe how they support the conclusions reached. Discuss limitations and the generalisability of the findings and how the findings fit with current knowledge.	Pg 9-10, line 186-253
Other			
Source of funding	23	Describe how the study was funded and the role of the funder in the identification, design, conduct, and reporting of the analysis. Describe other non-monetary sources of support.	Pg 11, line 272
Conflicts of interest	24	Describe any potential for conflict of interest of study contributors in accordance with journal policy. In the absence of a journal policy, we recommend authors comply with International Committee of Medical Journal Editors recommendations.	

For consistency, the CHEERS Statement checklist format is based on the format of the CONSORT statement checklist

The **ISPOR CHEERS Task Force Report** provides examples and further discussion of the 24-item CHEERS Checklist and the CHEERS Statement. It may be accessed via the *Value in Health* link or via the ISPOR Health Economic Evaluation Publication Guidelines – CHEERS: Good Reporting Practices webpage: http://www.ispor.org/TaskForces/EconomicPubGuidelines.asp

The citation for the CHEERS Task Force Report is:
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Modelling the cost of community interventions to reduce child mortality in South Africa using the Lives Saved Tool (LiST)

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Abstract

Objective To estimate the costs and impact on reducing child mortality, of scaling up interventions that can be delivered by community health workers at community level from a provider's perspective.

Setting In this study we used the Lives Saved Tool (LiST), a module in the spectrum software. Within the spectrum software, LiST interacts with other modules, the AIDS Impact Module (AIM), Family Planning Module (FamPlan) and Demography Projections Module (Dem Proj), to model the impact of more than 60 interventions that affect cause-specific mortality.

Participants Demography Projections Module Based on National South African Data

Interventions A total of 9 interventions namely; Breastfeeding promotion, Complementary feeding, Vitamin supplementation, Hand washing with soap, Hygienic disposal of children's stools, Oral rehydration solution, Oral antibiotics for the treatment of pneumonia, Therapeutic feeding for wasting, and Treatment for moderate malnutrition.

Primary and secondary outcome measures Reducing child mortality

Results A total of 9 interventions can prevent 8, 891 deaths by 2030. Hand washing with soap (21%) accounts for the highest number of deaths prevented, followed by therapeutic feeding (19%) and oral rehydration therapy (16%). The top 5 interventions account for 77% of all deaths prevented. At scale, an estimated cost of US$169.5 million (US$3 per capita) per year will be required in community health worker costs.

Conclusion The use of community health workers offers enormous opportunities for saving lives. These programmes require appropriate financial investments. Findings from this study show what can be achieved if concerted effort is channelled towards the identified set of life saving interventions.

Strengths and limitations of this study

- The Lives Saved Tool (LiST) is a widely used robust priority setting tool that has been extensively reviewed and used to influence policy in low and middle income countries.
- The model used in this analysis offers an alternative to measured impact of community health interventions, which can be costly undertakings.
- One limitation of this analysis is that interventions for saving the lives of children are included as standalone interventions and not packages of care, thus the overall impact is potentially overestimated.
- While intervention costs are provided, this study is not a full economic evaluation, which only considers costs of labour, drugs and supplies associated with the essential interventions.

Background

More than 40,000 children under the age of five years die every year in South Africa from preventable causes, mainly diarrhoea and pneumonia [1,2]. Progress has been made in the last decade, with child and infant mortality reducing significantly. Under-five mortality reduced from 56 deaths per 1,000 live births in 2009 to 39/1,000 in 2014, and infant mortality from 39/1,000 (2009) to 28/1,000 (2014) [3]. This progress has occurred at a time during which there has been rapid scale up of prevention of mother to child transmission (PMTCT) of HIV and improvement in the coverage of other essential child health interventions including immunisations and increased access to water and sanitation. However, this has not been sufficient to reach the country's millennium development goals of reducing infant and under-five mortality rates by two thirds by 2015.

As the country looks to a new set of sustainable development goals beyond 2015, there is need to focus on essential interventions that have been shown to be effective in improving child health. Recent analyses in South Africa identified a set of priority interventions that can have an impact on stillbirths [4], maternal, newborn and child mortality [5]. Interventions such as family planning can

avert more than 7,000 newborn and child lives, at a cost of US$7 per year per user of family planning [6]. Investing an additional US$9 to US$18 per capita in 13 interventions to prevent diarrhoea can save more than 3,000 additional child lives every year [7]. Scaling up these essential maternal and child health interventions will require concerted effort and a strengthening of the health system, a process which has already been initiated by the government.

In 2011, South Africa initiated its primary healthcare (PHC) reengineering programme in a bid to improve health systems performance and access to health. PHC re-engineering is aimed at positioning PHC as the mainstay of the health sector in responding to the quadruple burden of disease (HIV/TB; maternal and child health; non-communicable burden of disease; and violence and injury). South Africa's approach to PHC reengineering relies heavily on PHC outreach teams which include professional nurses, health promotion practitioners and community health workers (CHWs).

Global evidence has shown that CHWs can effectively deliver interventions in primary health care including nutrition, maternal and child health, malaria control, tuberculosis (TB) control, HIV/AIDS prevention and control, mental health and non-communicable disease [8-13]. A Cochrane review of CHW interventions identified 107 randomised controlled trials which showed promising benefits, compared to usual facility care in increasing immunisation uptake in children, improving breastfeeding rates until six months, reducing neonatal mortality and improving pulmonary TB care rates [14]. The review also reported that CHWs interventions reduce child morbidity and mortality; maternal mortality; and increase the likelihood of caregivers seeking care for children who are ill.

There is a small but growing evidence base of cost effectiveness studies of CHW interventions in low and middle income countries [15,16]. More recently there is evidence of the cost-effectiveness of CHW interventions in reducing malaria and asthma [17], mortality of neonates and children [17], malnutrition [17], and increasing exclusive breastfeeding [18,19], and increasing uptake of home

based HIV testing [20]. However, there is still a need to provide more information on the cost and impact of community health worker interventions, in order to aid priority setting and decision making for the improvement of child health.

In this paper, we use the Lives Saved Tool (LiST), a widely used priority setting tool, to estimate the costs of scaling up interventions that can be delivered by CHWs at community level [21]. LiST has been previously used in South Africa to identify the essential interventions that can save the lives of children, together with the costs of these interventions [5-7, 26, 27]. It has also been used in other low and middle income countries to assess the cost-effectiveness of community health worker programmes [15]. Our paper describes the methods used in LiST to estimate the cost of deploying CHWs and the overall impact that the selected interventions can have on reducing child mortality. This information is necessary for South Africa, as it pursues the goal of Universal Health Care.

Methods

This analysis used the Lives Saved Tool (LiST), a module in the Spectrum software, which models the impact of increased coverage of health interventions on maternal, newborn and child mortality [21]. Within the Spectrum software, LiST interacts with other modules, the AIDS Impact Module (AIM), Family Planning Module (FamPlan) and Demography Projections Module (DemProj), to model the impact of more than 60 interventions that affect cause-specific mortality [22]. LiST is a deterministic mathematical model that compares the effect of various interventions on population level risk factors, as well as stillbirths and maternal, newborn and child deaths [21,23]. The primary model inputs are coverage of interventions and the outputs are changes in risk factors (such as stunting rates) and cause specific mortality. Interventions included in the model can have an impact on single or multiple causes of death and risk factors, with outcomes changing based on the level of intervention coverage. Increasing the level of coverage of one or more interventions can thus lead to a reduction in associated risk factors or cause-specific mortality.

Intervention impact on mortality can be direct or indirect (through the reduction of risk factors). The direct impact of each of these interventions is modelled by multiplying its effectiveness estimate with the level of coverage, assuming all other interventions are kept constant. For example, an intervention with an effect estimate of 30% can avert 30% of the associated cause-specific deaths if coverage for that intervention is 100%.

The modelling methods used in LiST have been used in several studies [24,25]. In South Africa, LiST has been used to identify the potential cost and impact of scaling up interventions on stillbirths [4], diarrhoea [26] and maternal, newborn and child mortality [5,27]. In our model, we use LiST to model the impact of interventions to reduce child mortality and then estimate the resources required for the portion of interventions that are delivered at community level [28].

Nine interventions (described in Table 1) available in LiST that can be delivered at community level, and have been shown to effectively impact child mortality are used in the model. The focus on these interventions was because they can be delivered by CHWs at community level. The baseline coverage of all interventions included in LiST was maintained, and only scaled up for the 9 community interventions, from baseline levels (2015) to full coverage at 99% (2030). Increases in coverage were assumed to be gradual and interpolated over the 15 year period.

The baseline mortality rates used were 41 deaths per 1,000 live births for under-five children and 13/1,000 for neonates [29]. The causes of newborn and child mortality [30] are given in Figure 1. The relationship between the 9 interventions scaled up in the model and the causes of death are shown in Table 1. The interventions are mainly focused on diarrhoea.

Table 2 shows the percent delivery of each intervention at different levels in the base and target years. Taking promotion of breastfeeding for example, the table shows that in the base year, the coverage of this intervention is 25% and will be scaled up to 99% in the target year 2030. In the base year, breastfeeding promotion is delivered 50% at community level and 25% each at outreach and clinic levels. While we assumed that overall intervention coverage for the 9 interventions increased, the level assigned to each delivery channel remained the same. Setting the percent delivery is essential to determining the resource requirements at the different levels. It is also important to note that LiST models the overall impact of each intervention, and intervention impact does not take into consideration the model of delivery (whether delivered at community or facility level).

Estimation of costs and resource requirements

Costs were modelled from a provider perspective, using the costing module in LiST. The module uses an ingredients approach to costing, based on four components: personnel and labour; drugs and supplies; other recurrent costs; and capital costs. In the analysis for costs of community health workers, the items included are personnel and labour and drugs and supplies. Staff remuneration is based on current salary structures of health workers in South Africa, with an allowance made for annual cost of living adjustments at 5.6% per annum [31]. The unit costs of drugs and supplies are based on international drug prices from UNICEF and the Management for Sciences Health International Drug Price Indicator [32,33].

The primary personnel input in LiST are staff time, which is then converted to annual staff costs. Thus, LiST cannot for example calculate the number of personnel required for a particular intervention, but can be used to estimate the effort required to scale up an intervention (in terms of staff time).

Costs were estimated in South African Rand (ZAR) and converted to United States Dollars (US$), at an average exchange rate of US$1 to ZAR13 in 2015. All costs were adjusted to 2015 using the Consumer Price Index (CPI).

Results

The model estimates a total fertility rate of 2.4, approximately 1.4 million pregnancies and 1.2 million births in 2015. The projected number of pregnancies and births in 2030 reduces to 1.2 million and 1 million, respectively.

Overall intervention impact on child mortality

Table 3 provides the estimated number of deaths at baseline in 2015 and after full scale in 2030. The number of deaths reduces from approximately 40,214 in 2015 to 30,004 in 2030. Thus a 10,210 deaths are prevented in this period, out of which a total of 8,322 deaths prevented are attributed to the 9 community interventions that were scaled up in this analysis (Table 4). Hand washing with soap (22%) accounts for the highest number of deaths prevented, followed by therapeutic feeding (21%) and ORS (17%). The top 5 interventions account for 82% of all deaths prevented.

Estimations of resource requirements

The total costs of all the interventions used in the analysis (including costs of all delivery channels i.e. community, outreach and health facility) are estimated to be US$74 million (US$1 per capita) in 2015. This is expected to rise to US$565 million (US$10 per capita) if interventions are scaled up to 99% coverage in 2030. In comparison, the costs of the community component are US$19.8 million (US$0.37 per capita) in 2015 and US$169.5 million in 2030. The difference in the total and community costs shows the impact that a higher cadre of staff would have in relation to costs. The required number of workers was calculated by converting the personnel time estimated in LiST.

Considering only the baseline costs at community level, hygienic disposal of stools is estimated to have the highest cost of labour at US$5.7million. Therapeutic feeding for wasting comes in second at US$5.6 million and oral rehydration solution has the third highest cost of US$2.6 million. When interventions are at scale in 2030, the highest costs are projected for treatment of moderate acute malnutrition (US$54 million), hand washing with soap and disposal of stools (US$37 million each) and therapeutic feeding for wasting (US$37 million).

Approximately 3.3 million hours of work per year at the community level are required at baseline, compared to 11.1 million hours when interventions are fully scaled up. Based on a full time equivalent working a 6 hour day for a full year, we the required community health workforce to deliver the interventions used in this model will be about 3,000 at baseline and 11,000 at full coverage.

Discussion

This analysis used the Lives Saved Tool (LiST), a widely used priority setting tool, to estimate the cost and impact of interventions delivered at community level to prevent child mortality. The results show that scaling up 9 interventions that are conducted at both community and facility level can prevent an additional 8,300 lives per year. The top 5 interventions: hand washing with soap, therapeutic feeding for wasting, ORS, oral antibiotics for pneumonia and appropriate complementary feeding, account for 82% of all additional deaths prevented i.e. implementing only these 5 interventions at scale can prevent an additional 6,800 child deaths per year.

This is an important finding as it has implications for considerations when choosing the most effective interventions to meet the new sustainable development goals for child health. Considering that not all interventions can be fully implemented given budgetary constraints, focusing on the

identified 5 most effective interventions can contribute to achieving the desired results. Other considerations such as cost implications have to be made when choosing which interventions to implement.

In 2011, it was estimated that there were more than 72,000 community health workers in South Africa, delivering various interventions [34]. In our projection, we estimated that approximately 11,000 community health workers would be required to deliver the 9 interventions used in this analysis at scale. This could be an underestimate, and we have no basis for comparisons with other studies. Caution should be taken when considering our estimate, because it is based on a projected baseline level of coverage for the modelled interventions, level of effort required to deliver the interventions and an annual salary, all of which could be different in other models.

The labour costs of community health workers have been provided in this analysis. We show that at scale, an estimated cost of US$169.5 million (US$3 per capita) per year will be required. The top 5 most effective interventions are also the most costly, probably because they are more personnel intense, with a lot of time spent on extensive demonstrations. Provision of oral antibiotics for example requires diagnosis, treatment and follow up. It is important to note though, that the overall cost of an intervention will be influenced by among other things, the level of coverage, with more effort required to scale up low coverage interventions.

The costs provided in this analysis are likely an underestimate of the true costs of deploying community health workers, which have been shown to be substantial. Equipment costs have not been included, nor have the usually large administrative costs also been considered. Future research should look into providing the overall cost structure as this has important implications for how health workers are deployed and accounted for. Future analyses should take these costs into

consideration, as it has been shown that they can contribute to the overall cost-effectiveness of interventions [35,36].

This analysis also had a limitation in that it did not consider the interventions included as part of a package of interventions that can be delivered by a single health worker. The interventions are standalone. While looking at the individual impact of interventions is useful and can help to understand the value of each intervention, this does not truly reflect the way most interventions are implemented in reality, as packages. It is therefore possible that we potentially overestimated the overall health impact of the interventions included in this analysis. Further, we also could have overestimated the costs, since savings tend to be higher when interventions are packaged than when they stand alone. However, other considerations should also be made on how packaged community health services would work and on whether a single health worker loaded with several different messages to deliver to a home will be as effective as one who is focused on one specific message, e.g. breastfeeding promotion.

The interventions included in this analysis have been shown to be effective in reducing child mortality. Extensive reviews of the literature were undertaken to gather information on intervention effectiveness by the Child Health Epidemiology Reference Group (CHERG) [37]. In this analysis, we have shown the potential impact that these interventions can have on reducing child mortality in South Africa. However, cognisance should be taken of the challenges that could be faced with deploying CHWs in the South African context. Health care in South Africa remains mainly facility based, and provided by professional health workers, while CHWs mainly facilitate health promotion. Therefore, an intervention such as case management of pneumonia, which requires some level of diagnostic ability as implemented in other settings [38,39], might not work for CHWs in South Africa. A lot of effort will have to be placed in training CHWs and redefining their roles. Such efforts would

incur costs that have not been considered in this study. The usefulness of our study is that it puts forward evidence that can be used to argue for the expansion of the roles of South African CHWs.

We focused on only 9 interventions that can be delivered at community level, by maintaining constant coverage of other child health interventions. This may not be very realistic since in the real world, coverage of the other interventions is likely to increase, resulting in a lower burden of under-five mortality by 2030. It is therefore possible that we have overestimated the total number of deaths prevented.

Furthermore, the LiST model assumes that the health system interventions are delivered at uniformly high quality. This is unlikely given drug shortages, health care worker attitudes and institutional challenges. Significantly more resources are probably required to address such issues.

Conclusion

South Africa has made significant progress with regard to reducing child mortality although this was not sufficient to meet the MDG deadline in 2015. As the new sustainable development goals materialise, and South Africa heads towards Universal Health Care, understanding what the best package is and how it can be delivered is essential. In order to do this, there is need to consider essential and effective interventions that will have the most impact on saving the lives of South African children. In this paper, we have provided information on the cost and impact of 9 effective interventions that can be delivered at community level. We show that implementing just 5 of these interventions can prevent as many as 6,800 additional deaths of children every year. The community health worker costs of implementing the 9 interventions do not seem to be substantial, at R41 per capita. This seems to be well within the scope and affordability of the South African health budget.

Contributorship statement LN and KH conceived the study and participated in the design. LN and LC conducted the analysis of the analysis of the data. All authors participated in interpretation of data, drafting and critical revision of the manuscript, and approved the final version.

Competing interests None declared

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Data sharing statement The model data can be made available to interested researchers

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414 Table 1: Description of interventions

Intervention	Description of the intervention	Cause of death affected	Effect estimate
1. Breastfeeding promotion	Breastfeeding promotion can be either one-on-one or group meetings. It is assumed that children 1-5 months of age who are exclusively breast fed do not need breastfeeding promotion.		
2. Complementary feeding	This intervention only benefits children 6-24 months of age who are living on more than a dollar a day; This can be delivered in the home, community or clinic, by health professionals or health volunteers. It includes the assumption that breast feeding should be continued for children 6-24 months of age, (but does not affect breast feeding rates). The intervention includes education on the proper foods to prepare as well as appropriate hygiene for food preparation.		
3. Vitamin A supplementation	This intervention covers the percent of children 6-59 months receiving full coverage with Vitamin A. Full coverage of Vitamin A supplementation is considered to be 2 doses of Vitamin A in the past year. It is assumed that all children in a country with Vitamin A deficiency are in need of Vitamin A for prevention.	Diarrhoea	47%
4. Hand washing with soap	Appropriate hand washing is defined as washing hands with soap, ash or other materials and using adequate water, after handling faeces and before preparing food.	Diarrhoea	48%
5. Hygienic disposal of children's stools	Percent of children's stools that are disposed of safely and contained. Stools are considered to be contained if: 1) the child always uses a toilet/latrine, 2) the faeces are thrown in the toilet or latrine, or 3) the faeces are buried in the yard.	Diarrhoea	20%
6. Oral rehydration solution (ORS)	Percent of children with diarrhoea given ORS from sachets. This includes sachets or pre-mixed solutions of ORS.	Diarrhoea	93%
7. Oral antibiotics for the treatment of pneumonia	Proportion of children 1-59 months with suspected pneumonia or ARI treated with antibiotics	Pneumonia	70%
8. Therapeutic feeding for wasting	Percent of wasted children receiving therapeutic feeding. Therapeutic feeding is outpatient treatment for severely wasted children (<-3Z) including supplementation with food (such as PlumpyNut) and maternal education. Therapeutic feeding is only applied to the percent of children severely wasted. It shifts children from the severely wasted category to moderately (-3to-2Z) and mildly (-2to-1Z) wasted categories.	Other causes	20%
9. Treatment for moderate malnutrition	Percent of moderately wasted children (-3to-2Z) receiving outpatient treatment including supplementation with food (such as PlumpyNut) and maternal education. Treatment for MAM shifts children from the moderately wasted category into the mildly wasted category (-2to-1Z).	Other causes	20%

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Table 2: Percent intervention coverage and delivery at different levels

	Coverage		Delivery channels					
			Community		Outreach		Clinic	
Interventions	Baseline year	Target year	Baseline year	Target year	Baseline year	Target year	Baseline year	Target year
Promotion of breastfeeding	25	99	50	50	25	25	25	25
Complementary feeding--education only	10	99	50	50	0	0	50	50
Vitamin A supplementation	50	99	50	50	50	50	0	0
Hand washing with soap	17	99	100	100	0	0	0	0
Hygienic disposal of children's stools	40.5	99	100	100	0	0	0	0
ORS - oral rehydration solution	50	99	50	50	0	0	50	50
Oral antibiotics : case management of pneumonia in children	73.2	99	50	50	0	0	50	50
Therapeutic feeding - for severe wasting	45	99	20	20	0	0	80	80
Treatment for moderate acute malnutrition	10	99	20	20	0	0	80	80

Table 3: Total number of deaths (all interventions)

Age-group	Baseline	Scale up to 99%
	2015	2030
<1 month	13356	12435
1-59 months	26857	17569
Total (0-59 months)	40214	30004

Table 4: Additional deaths prevented by 9 community interventions, 2030

Intervention	Number of deaths prevented	% deaths prevented
Hand washing with soap	1828	22%
Therapeutic feeding - for severe wasting	1730	21%
ORS - oral rehydration solution	1426	17%
Oral antibiotics : case management of pneumonia in children	1025	12%
Appropriate complementary feeding	822	10%
Hygienic disposal of children's stools	543	7%
Vitamin A supplementation	394	5%
Promotion of breastfeeding	319	4%
Treatment for moderate acute malnutrition	235	3%
Total	8322	100%

Note: This table provides the additional number of deaths prevented attributable to the 9 community interventions scaled up to full coverage

Table 5: Costs and resource requirements (US$)

Interventions	2015 Total	2015 Community	2030 Total	2030 Community
Promotion of breastfeeding	1,123,509	561,754	10,038,173	5,019,086
Complementary feeding (education only)	1,149,336	122,720	25,679,246	2,741,903
Vitamin A supplementation	549,421	71,866	2,394,368	280,552
Hand washing with soap	2,375,468	2,375,468	37,526,223	37,526,223
Hygienic disposal of children's stools	5,659,204	5,659,204	37,526,223	37,526,223
Oral rehydration solution	19,270,311	2,575,185	34,500,213	4,086,458
Oral antibiotics : case management of pneumonia in children	3,298,578	378,909	10,045,584	1,106,962
Therapeutic feeding - for severe wasting	28,213,620	5,621,596	135,840,638	27,062,171
Treatment for moderate acute malnutrition	12,549,660	2,500,542	271,778,014	54,143,689
Total	74,189,107	19,867,246	565,328,681	169,493,266
Personnel time (hours)				
Community health workers		3,339,796		11,140,869

Total costs include costs of all delivery channels (community, outreach and health facility).

US$=United States Dollars

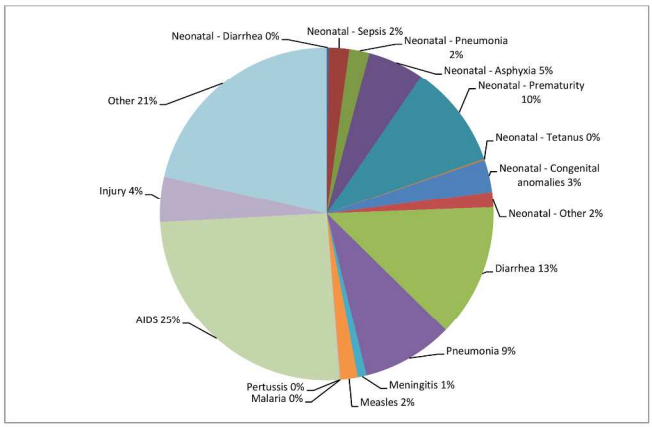

Figure 1: Causes of death in children under-five years, used in LiST (adapted from MRC, 2010).

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CHEERS Checklist
Items to include when reporting economic evaluations of health interventions

The **ISPOR CHEERS Task Force Report**, *Consolidated Health Economic Evaluation Reporting Standards (CHEERS)—Explanation and Elaboration: A Report of the ISPOR Health Economic Evaluations Publication Guidelines Good Reporting Practices Task Force,* provides examples and further discussion of the 24-item CHEERS Checklist and the CHEERS Statement. It may be accessed via the *Value in Health* or via the ISPOR Health Economic Evaluation Publication Guidelines – CHEERS: Good Reporting Practices webpage: http://www.ispor.org/TaskForces/EconomicPubGuidelines.asp

Section/item	Item No	Recommendation	Reported on page No/ line No
Title and abstract			
Title	1	Identify the study as an economic evaluation or use more specific terms such as "cost-effectiveness analysis", and describe the interventions compared.	Pg 1, line 1-2
Abstract	2	Provide a structured summary of objectives, perspective, setting, methods (including study design and inputs), results (including base case and uncertainty analyses), and conclusions.	Pg 2, line 21-40
Introduction			
Background and objectives	3	Provide an explicit statement of the broader context for the study. Present the study question and its relevance for health policy or practice decisions.	Pg 4-5, line 85-100
Methods			
Target population and subgroups	4	Describe characteristics of the base case population and subgroups analysed, including why they were chosen.	Pg 6, line 126-130
Setting and location	5	State relevant aspects of the system(s) in which the decision(s) need(s) to be made.	Pg 6, line 132-138
Study perspective	6	Describe the perspective of the study and relate this to the costs being evaluated.	????
Comparators	7	Describe the interventions or strategies being compared and state why they were chosen.	Pg 6, line 124-127
Time horizon	8	State the time horizon(s) over which costs and consequences are being evaluated and say why appropriate.	Pg 6, line 124-127
Discount rate	9	Report the choice of discount rate(s) used for costs and outcomes and say why appropriate.	Not applicable
Choice of health outcomes	10	Describe what outcomes were used as the measure(s) of benefit in the evaluation and their relevance for the type of analysis performed.	Pg 6, line 127-130
Measurement of effectiveness	11a	*Single study-based estimates:* Describe fully the design features of the single effectiveness study and why the single study was a sufficient source of clinical effectiveness data.	Not applicable

			Not applicable
	11b	*Synthesis-based estimates:* Describe fully the methods used for identification of included studies and synthesis of clinical effectiveness data.	Not applicable
Measurement and valuation of preference based outcomes	12	If applicable, describe the population and methods used to elicit preferences for outcomes.	Not applicable
Estimating resources and costs	13a	*Single study-based economic evaluation:* Describe approaches used to estimate resource use associated with the alternative interventions. Describe primary or secondary research methods for valuing each resource item in terms of its unit cost. Describe any adjustments made to approximate to opportunity costs.	Pg 5, line 114-152
	13b	*Model-based economic evaluation:* Describe approaches and data sources used to estimate resource use associated with model health states. Describe primary or secondary research methods for valuing each resource item in terms of its unit cost. Describe any adjustments made to approximate to opportunity costs.	Pg 5, line 154-155
Currency, price date, and conversion	14	Report the dates of the estimated resource quantities and unit costs. Describe methods for adjusting estimated unit costs to the year of reported costs if necessary. Describe methods for converting costs into a common currency base and the exchange rate.	Pg 7, line 157-158
Choice of model	15	Describe and give reasons for the specific type of decision-analytical model used. Providing a figure to show model structure is strongly recommended.	Pg 5-6, line 120-152
Assumptions	16	Describe all structural or other assumptions underpinning the decision-analytical model.	Pg 6, line 143-158
Analytical methods	17	Describe all analytical methods supporting the evaluation. This could include methods for dealing with skewed, missing, or censored data; extrapolation methods; methods for pooling data; approaches to validate or make adjustments (such as half cycle corrections) to a model; and methods for handling population heterogeneity and uncertainty.	Pg 6, line 127-138
Results			
Study parameters	18	Report the values, ranges, references, and, if used, probability distributions for all parameters. Report reasons or sources for distributions used to represent uncertainty where appropriate. Providing a table to show the input values is strongly recommended.	Pg 7, line 167-183
Incremental costs and outcomes	19	For each intervention, report mean values for the main categories of estimated costs and outcomes of interest, as well as mean differences between the comparator groups. If applicable, report incremental cost-effectiveness ratios.	Pg 7, line 167-183
Characterising uncertainty	20a	*Single study-based economic evaluation:* Describe the effects of sampling uncertainty for the estimated incremental cost and incremental effectiveness parameters, together with the impact	Not applicable

			Not applicable
		of methodological assumptions (such as discount rate, study perspective).	Not applicable
	20b	*Model-based economic evaluation:* Describe the effects on the results of uncertainty for all input parameters, and uncertainty related to the structure of the model and assumptions.	Not applicable
Characterising heterogeneity	21	If applicable, report differences in costs, outcomes, or cost-effectiveness that can be explained by variations between subgroups of patients with different baseline characteristics or other observed variability in effects that are not reducible by more information.	Not applicable
Discussion			
Study findings, limitations, generalisability, and current knowledge	22	Summarise key study findings and describe how they support the conclusions reached. Discuss limitations and the generalisability of the findings and how the findings fit with current knowledge.	Pg 9-10, line 186-253
Other			
Source of funding	23	Describe how the study was funded and the role of the funder in the identification, design, conduct, and reporting of the analysis. Describe other non-monetary sources of support.	Pg 11, line 272
Conflicts of interest	24	Describe any potential for conflict of interest of study contributors in accordance with journal policy. In the absence of a journal policy, we recommend authors comply with International Committee of Medical Journal Editors recommendations.	

For consistency, the CHEERS Statement checklist format is based on the format of the CONSORT statement checklist

The **ISPOR CHEERS Task Force Report** provides examples and further discussion of the 24-item CHEERS Checklist and the CHEERS Statement. It may be accessed via the *Value in Health* link or via the ISPOR Health Economic Evaluation Publication Guidelines – CHEERS: Good Reporting Practices webpage: http://www.ispor.org/TaskForces/EconomicPubGuidelines.asp

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